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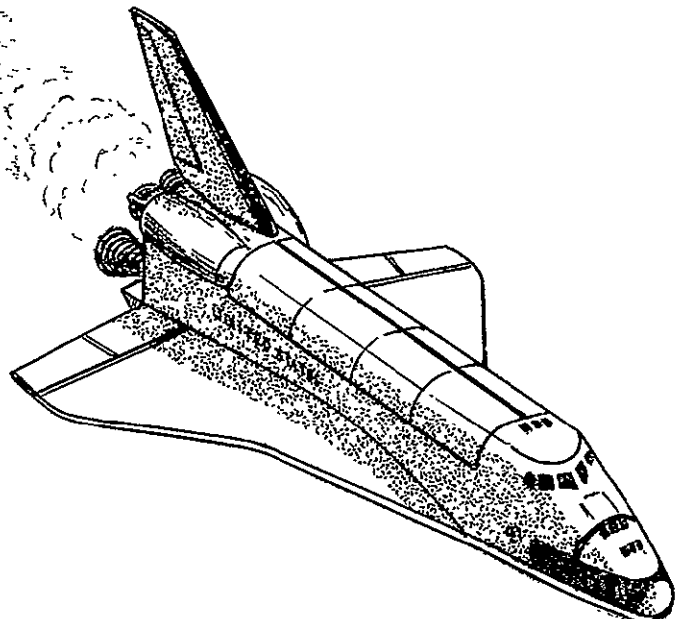
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1977 YEARLY REPORT

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**SOLVING MANUFACTURING PROBLEMS
THROUGH AEROSPACE TECHNOLOGY**



REPORT NO. IITRI-H6056 - YEARLY REPORT

MANUFACTURING PROCESS APPLICATIONS TEAM
(MATEam)

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YEARLY REPORT FOR 1977

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FOREWORD

This report describes the activities of IIT Research Institute's Manufacturing Applications Team (MATEam) during the first program year, February 1, 1977 to January 19, 1978. The purpose of the team is to effect widespread transfer of NASA technology to aid in the solution of manufacturing problems in the industrial sector of the economy.

During the first year of the program, the team has focused on: identifying manufacturing problems, or technology opportunities; seeking out relevant NASA technology in order to help solve the problems; assessing the technical and economic merits of the potential solutions; developing strategies for commercialization; and initiating industry implementation. To date, the team has had contact with more than 450 companies, industry associations and government agencies, documented 150 manufacturing problems, and identified 20 potential technology transfers. Although none of the technology transfers have been completed (i.e., have been commercialized and are being used), several are currently in the applications engineering phase, while others are in early stages of implementation and should be completed during the next program year.

In addition to the authors, the following staff have made significant contributions to the program: J. Dylik, P. Grinstead, M. Hill, T. Jacobius, J. O'Connor, M. Ross, and Y. Shikari. The report was typed by D. Schuh and M. Wroblewski.

The work described herein was conducted under NASA Contract NAS8-32229. Mr. James Eh1, Marshall Space Flight Center, served as the Contracting Officer's Representative.

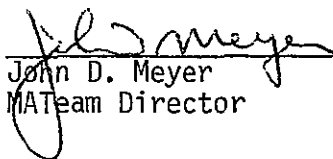
Respectfully submitted,

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JDM:ds


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1. SUMMARY

During the first year of its operation, the MATEam has made significant progress transferring aerospace technology to the manufacturing sector of the economy.

The MATEam program has been well received by industry. During the past year, the team members have had contact with over 450 companies, industry associations and other government agencies. Thirteen presentations on the MATEam have been given at various conferences and meetings. The presentations to the National Machine Tool Builders Association and the Industrial Perforators Association were particularly noteworthy in that these organizations are considering the formation of committees to interface with the team on a regular basis.

To date 150 manufacturing problems on technology opportunities have been identified and documented. Thirteen of these problems have been screened and 20 potential technology transfers have been identified.

Most notable of the potential transfers include, An A-C Motor Power Factor Control that reduces the energy required to operate small motors; a Computerized Tracking and Torch Manipulation Welding System (Weld Skate); Computer Aided Design of Sand Casting Molds; Automatic Laser Inspection of Printed Circuit Boards; and Tool Wear Sensing Using Vibrational Analysis. Although none of the technology transfers have been completed (e.g., commercialized and implemented), several are entering the applications engineering phase and should reach completion during the next year or two.

In summary, the MATEam has been well received by industry; strong communications channels have been established between the team, NASA, individual companies, industry associations and other government agencies.

2. INTRODUCTION

2.1 Objectives

The objective of the MATEam is to successfully transfer aerospace technology to solve key problems in the manufacturing sector of the economy. The underlying purpose for the team is to increase the return on the nation's investment in aerospace research by fostering wide implementation and use of NASA technology and expertise. The function of the team in accomplishing this objective is to provide an important intermediary role between technology sources and technology users in order to: improve the communication process; assist in the movement of new technology across organizational and disciplinary boundaries; and shorten the time between technological development and its broad and effective implementation.

NASA's decision to sponsor an applications team to effect technology transfer in manufacturing was both timely and appropriate. The United States, while still ahead of other industrialized nations in terms of overall manufacturing capabilities, productivity and state of technology, is finding its leadership position diminishing. The problem is becoming increasingly severe because of the continual rise in the cost of energy, raw material and labor and the need to maintain our competitive position in the world market. Clearly, a way to combat this growing national problem and maintain our competitive advantage is to capitalize upon and speed up adaptation of new manufacturing technologies and equipment into the industrial sector. The appropriateness of NASA's decision is underscored by the fact that the areas of science and technology in which they have been actively advancing the state-of-the-art correspond closely to those needed by the industrial sector of the economy to improve manufacturing productivity.

2.2 Program Approach

Achieving significant technology transfer, widespread implementation, usage of new products, and processes is not something that occurs quickly. To bring about successful technology transfer, industry problem areas, or market needs, must be matched with solutions that are both technically sound and economically feasible. This matching of needs with solutions does not, however, guarantee technology transfer; it is also necessary to establish effective means for commercializing the new product or process. Thus the MATEam's task is somewhat analogous to that of identifying and implementing new business opportunities and carries with it the many pitfalls normally associated with new venture development groups.

The approach used by the MATEam is structured to insure that the team's efforts are focused on bringing about successful technology transfer and that common pitfalls are avoided. Key elements of the approach are described below.

2.2.1 Industry Interaction

Effective communication channels between the team, industry associations, individual companies, NASA personnel and other government agencies is necessary to coordinate the teams efforts throughout all phases of the technology transfer process, from identification of technology opportunities to commercialization and implementation of new processes and equipment. The MATEam provides this interaction through numerous presentations to industry groups, visits to companies for in-plant discussions of problems and potential solutions, and extensive consultation by phone and mail. To help foster this type of interaction, there is no fee charged to industry for the team's services.

As an added means of increasing the team's effectiveness, it is concentrating on four target industries. In this way, the team can develop a close working relationship with the target industries and not

dilute its efforts by trying to cover all industry types. This does not mean, however, that the team has not or will not work with companies outside the target categories if it appears that meaningful technology transfer can be achieved. The four target industries are:

- Machine tool builders
- Light fabrication and assembly
- Heavy equipment manufacturers
- Electronics assembly

2.2.2 MATeam Technology Transfer Process

There are two basic approaches which can be used to effect technology transfer: 1) to use the technology available as a basis for initiating the transfer process and then seek out applications for that technology, or 2) to begin the transfer process by identifying the technology needs of the target industry sector and then determine if relevant technology is available to satisfy those needs. The latter approach is the one used by the MATeam.

Starting the technology transfer process with identification of industry needs rather than the aerospace technology available provides several distinct advantages. First, it helps insure that the team is responsive to the needs of industry. Second, it provides a ready market for the aerospace technology if it can be found, thus helping to insure rapid commercialization and implementation. Additionally, by documenting the technology opportunities and circulating them to appropriate NASA personnel, the effectiveness of the search for relevant technology is increased and, in some cases, may even result in innovative solutions to problems because of the unique technical expertise of NASA personnel. Last, starting with industry problems rather than the available technology helps insure that the team's efforts are spent on areas of greatest need and payback and not in trying to bring about solutions for which there is no real problem.

An overview of the MATEam technology transfer process is shown in Figure 2-1 on the next page. It represents a logical sequence of steps, beginning with the identification and documentation of industry technology opportunities, or problem areas, and ending in successful technology transfer.

The MATEam identifies manufacturing problems, or technology opportunities, by working with professional societies, industry associations, various government agencies and individual companies. Once identified, problems are documented in the form of problem statements, which are used by the MATEam throughout the technology transfer process. Problem statements play a key role in the MATEam's activities. They serve as a means of communicating information about the problem so that team members can:

- Seek out potential solutions
- Evaluate the likelihood of successfully solving a problem and implementing a solution, and
- Compare problems and concentrate on those which have the highest likelihood of solution and potential benefit.

In addition to its internal use, the MATEam circulates edited copies of the problem statements to technical personnel in the NASA field centers and laboratories. This helps insure that every effort is made to identify appropriate technology if it exists. The problem statements are edited prior to circulation to NASA personnel to reserve the name of the problem originator and any information of a proprietary nature.

Copies of the problem statement are not circulated outside of NASA or the MATEam until a potential solution has been identified. If a potential solution has been identified, other organizations may be contacted to assess the magnitude of the problem and the suitability of the potential solution. Unedited problem statements are not circulated under any circumstances. Additional information on the content and format of problem statements is contained in Appendix A.

MATEAM TECHNOLOGY TRANSFER PROCESS

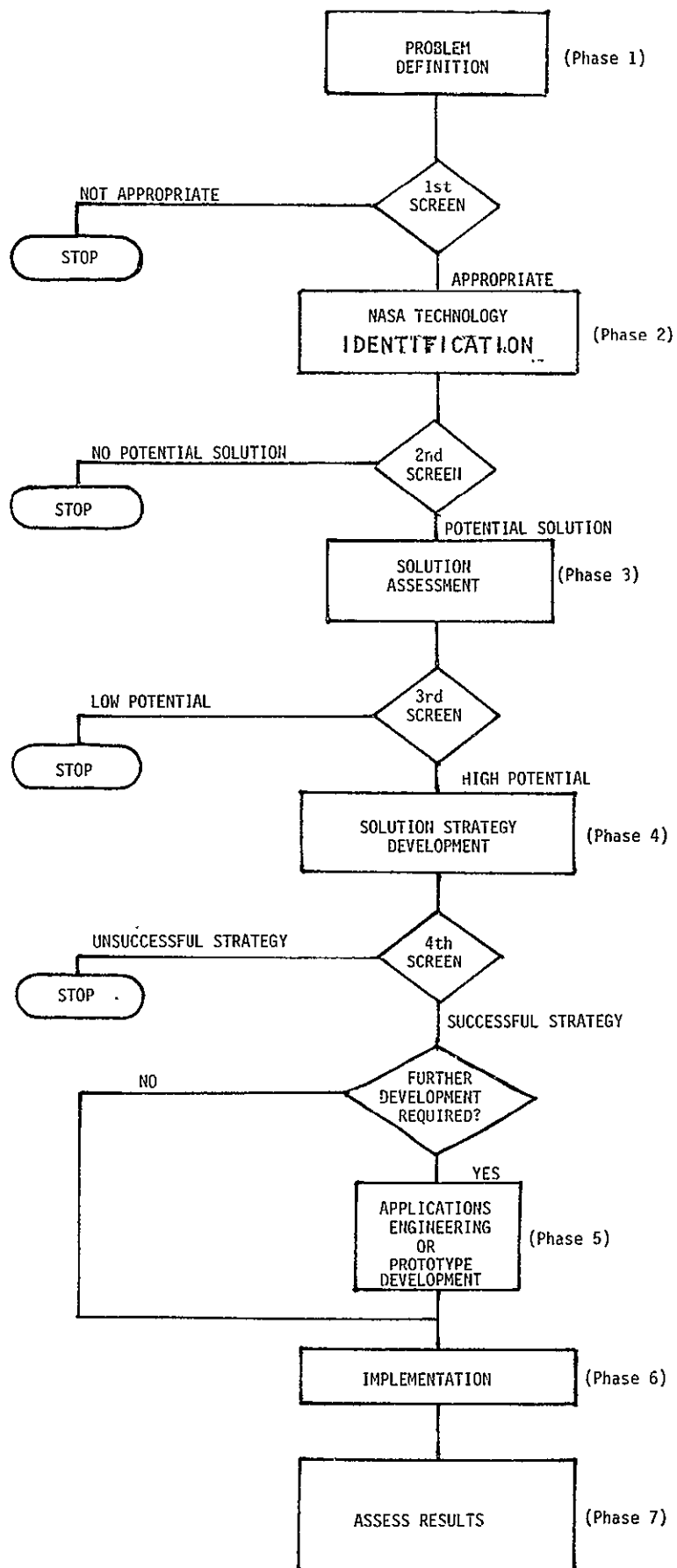


Figure 2-1

Problems which the MATEam will work on must meet three criteria:

- The problem must be manufacturing related.
- The problem must apply to more than one company.
- Solutions to problems must be based on NASA technology.

The problem statements are screened at several stages during the technology transfer process. The questions asked during the screening are:

- Do satisfactory commercial solutions already exist for this problem?
- What is the likelihood of identifying relevant NASA technology?
- What is the magnitude of the benefits to be gained by solving the problem?
- Can the problem be solved technically?
- Can a solution be implemented?

The answers to these questions are used to select those problems which the MATEam can most effectively solve. Criteria used for the initial screening are contained in Appendix B. In those instances where a problem statement does not pass the screening process, the problem originator is notified and told the reason for the decision.

Those problem statements which survive the preliminary screening (i.e., are deemed suitable for the team) then enter the next phase of the technology transfer process: identification of relevant NASA technology which could provide wholly or in part, a solution. This is accomplished through data and literature searches utilizing NASA's Scientific and Technical Information Facility, annual STAR indices, review of NASA Tech Briefs and by contacting individual NASA personnel with the necessary expertise for further discussions of the technology involved.

Following the identification of relevant NASA technology, each potential solution is given a more in-depth analysis. The solutions are assessed in terms of impact of solving the problem, likelihood of

successful solution and implementation, resources required to effect commercialization and organizations which should be involved.

If the solution still appears valid after this assessment, the team then develops an implementation strategy to bring about commercialization. Such factors as applications engineering and implementation costs and the proper time phasing of the implementation are taken into consideration when developing the implementation strategies. Inputs from the problem originator and NASA personnel are solicited in devising these strategies. The particular implementation strategy that is developed will depend on the individual case in point, but in general, the strategy will be one of the following types:

- Direct transfer of the solution information and immediate implementation by the user.
- Applications engineering followed by test and implementation totally funded by the user or someone in a position to commercialize the process or product.
- Applications engineering jointly funded by the user/commercializer and NASA with subsequent test and implementation by the user/commercializer.

Once an implementation strategy is agreed upon between the MATEam, NASA, the problem originator and a commercializer, implementation is initiated. It should be pointed out that successful technology transfer and implementation takes varying amounts of time to come to fruition, depending on the specific case. Some can occur fairly rapidly, while others will take more time because of applications engineering and the type of industry and technology involved.

In order to achieve the maximum possible implementation, the team widely disseminates data pertaining to successful technology transfers. This dissemination of information is accomplished through press releases and articles in appropriate trade journals, magazines, etc., and presentations at conferences and other meetings.

2.3 Team Organization

Responsibility for the MATEam resides in the Technology Transfer and Market Research Section at IITRI. The team organization is shown in Figure 2-2. The team members possess a unique mix of capabilities and experience in manufacturing technology and technology transfer for a variety of industries. In addition to the individuals listed in Figure 2-2, the team also relies extensively on staff members within other IITRI research divisions for their expertise in specialized areas relating to manufacturing processes and equipment.

The remainder of this report presents the MATEam's activities and progress during its first program year. Chapter 3 describes the contacts that have been made with industry. The technology opportunities which have been identified are highlighted in Chapter 4. The 20 potential technology transfers which the team is currently pursuing are discussed in Chapter 5, along with their status, and last, the conclusions and recommendations resulting from the first program year are covered in Chapter 6.

MANUFACTURING APPLICATIONS TEAM ORGANIZATION

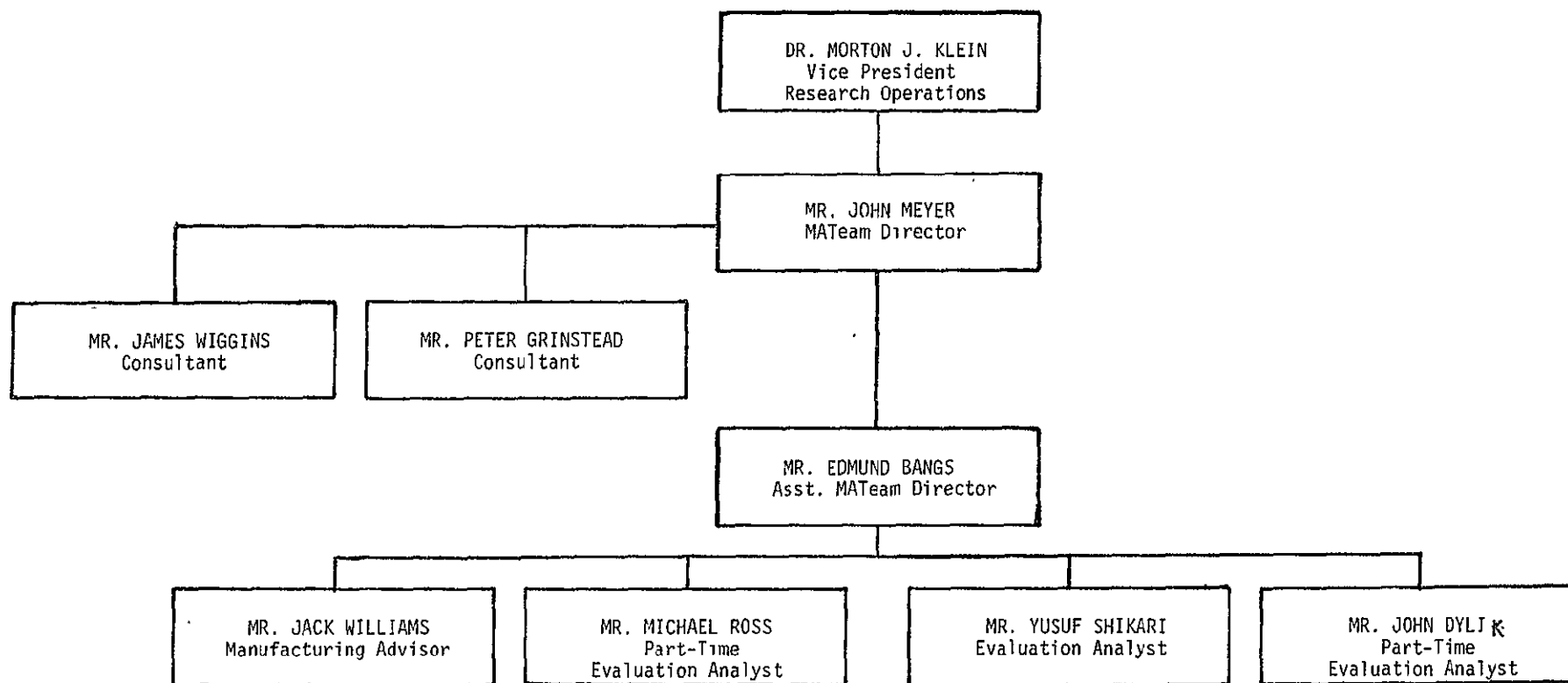


Figure 2-2

3. INDUSTRY CONTACTS

The MATEam was well received by industry during its first year. Approximately 467 contacts have been made with individual companies, industry associations and interested government agencies. A breakdown of the contacts by industry and type of contact is contained in Table 3-1.

Much of the industry interest was generated by a press release describing the MATEam program which was mailed to appropriate trade journals in April, 1977. A copy of the press release is contained in Appendix C. A similar press release was issued by NASA in April, 1977. A few of the publications which contained notices or articles on the team include:

- American Machinist
- Metalworking News
- Electronics Packaging and Production
- Mechanical Engineering (published by ASME)
- ALERT (published by Research Institute of America)
- Kiplinger Newsletter

Industry interest in the program was also increased by numerous presentations given by the team members at conferences and other meetings. The presentations given by the team members during the first year are listed in Table 3-2. The presentations given to the National Machine Tool Builders Association and the Industrial Perforators Association are particularly noteworthy in that both organizations are considering forming committees to interface with the MATEam. These committees would assist in identifying industry problems and evaluating potential solutions.

APPROXIMATE NUMBER OF MATEAM CONTACTS

<u>Industry</u>	<u>Mail/Phone</u>	<u>Visit To</u>	<u>Visit From</u>	<u>Total Contacts</u>
Machine Tool Builders	20	10	1	31
Heavy Equipment Manufacturers	20	3	0	23
Electronics Assembly	50	4	2	56
Light Fabrication and Assembly	100	4	3	107
Associations and Societies	10	5	0	15
Publications	10	0	1	11
Government Agencies	15	2	0	17
Other	200	0	4	207
				467

TABLE 3-1

MATEAM PRESENTATIONS

February 10, 1977	NASA-MSFC Contractors Technology Utilization Workshop, Chicago, IL
March 31, 1977	NASA Technology Utilization Meeting, Chicago, IL
April 5, 1977	NASA-MSFC Contractors Technology Utilization Workshop, Redondo Beach, CA
May 10, 1977	Advanced Manufacturing Methods Technical Meeting, Chicago, IL
June 16, 1977	Robot Institute of America, Dearborn, MI
June 22, 1977	REAPS Technical Meeting, New Orleans, LA
August 18, 1977	EIA Manufacturing Technology Committee, Hopkins, MN
September 15, 1977	National Machine Tool Builders Association, Chicago, IL
September 20, 1977	SME Chapter, Gary, IN
October 19, 1977	SME Chapter, Chicago, IL
October 5, 1977	DOD Manufacturing Technology Conference Orlando, FL
October 24, 1977	Industrial Perforators Assn. Hilton Head, SC
November 15, 1977	National Machine Tool Builders Assn. Chicago, IL
December 6, 1977	AIIE Conference Washington, D.C.
February 9, 1978*	American Society for Metals (Calumet Ill. Chapter)
April 9-12, 1978*	Numerical Control Society Annual Meeting Chicago, IL
April 26-28, 1978	15th Space Congress Cocoa Beach, Fla.

* Planned

TABLE 3-2
IIT RESEARCH INSTITUTE

4. MANUFACTURING PROBLEM OPPORTUNITY STATEMENTS

As mentioned in Section 2-2 of this report, the starting point for the MATEam technology transfer process is the identification and documentation of manufacturing problems or technology opportunities. During the past year, the team has prepared 150 such problem statements. The majority of these problem statements were a direct result of the industry contacts which had been made by the team, while others were generated by reviewing publications which describe current manufacturing technology needs. A breakdown of the problem statements by technical category is contained in Table 4-1. A list of the problem statement titles and their status is contained in Appendix D.

The status of the presentations, visits, contacts and problem statements is summarized in Table 4-2. (See Figure 2-1 for a description of the transfer process phases). Of the 150 problem statements, 51 have been inactivated for various reasons and 89 are still under consideration by the team.

Twenty potential technology transfers have been identified and are currently being pursued. The definition used for "potential technology transfer" is that the problem statement has, as a minimum, successfully passed the second screening stage and that relevant NASA technology has been identified. In addition to the 20 active potential technology transfers, another 4 potential transfers have been inactivated during the past year.

The 20 potential technology transfers and their status are presented in Chapter 5.

TECHNICAL CATEGORIES OF MATEAM PROBLEM STATEMENTS

Test and Inspection	21	Product Design	4
Production Equipment	20	Cleaning	4
Metallurgy	16	Adhesives	4
Instrumentation	15	Forming	4
Surface Finishes	10	Industrial Noise	3
Welding	7	Lubrication	3
Energy	5	Conformal Coating	2
Machining	5	Other	27
Total			150

TABLE 4-1

SUMMARY OF MATEAM ACTIVITIES (YEAR 1)

<u>Activity</u>	<u>Number</u>
Industry Presentations	14
Company Visits	31
Other Contacts (Phone, Mail, etc.)	467
Problems Identified	150
Problem Statements Prepared	150
1st Screening Completed	140
(Problems Failed 1st Screening)	(19)
NASA Technologies Identified	24
(Problems Failed 2nd Screening)	(28)
Solutions Assessed	8
(Solutions Failed 3rd Screening)	(4)
Solution Strategies Developed	4
(Solutions Failed 4th Screening)	0
Applications Projects Completed	0
Implementations Completed	0
Results Assessed	0

TABLE 4-2

5. POTENTIAL TECHNOLOGY TRANSFERS

The 20 potential technology transfers which are actively being pursued by the MATEam at the end of the first program year are listed in Table 5-1 on the following page. Descriptions of each of the transfers and their status are contained in the following sections of this chapter.

Most notable of the potential transfers are discussed below:

• MAT-86, The Adaptively Controlled Weld Skate, may be considered the technology closest to transfer. The industry source, a major supplier of welding equipment, has made several visits to IITRI and has visited the Marshall Space Flight Center to see the prototype device in operation. He is very interested in the system and has forwarded a proposal for the additional development that will be required to assist in its eventual commercialization. An RTOP is being prepared; upon its approval development work will commence. The manufacturer is well respected in the welding community and has a good reputation in providing reliable well designed equipment and products.

• MAT-71, Computer Aided Design of Sand Casting, has received considerable industrial attraction and is presently being further developed under Army Sponsored Project TARADCOM-(4785014), "Improved Foundry Casting Processes Utilizing Computer Aided Fluid Flow and Thermal Analysis". Major casting manufacturers have expressed an interest in the process and have made frequent contacts to the MATEam inquiring as to its status.

• MAT-19, The Power Factor Control System for AC Induction Motors, has the potential to transfer rapidly since it has the capability of reducing the electrical energy required to operate small electric motors. The MATEam is in the process of contacting selected manufacturers in the small electric motor industry.

POTENTIAL TECHNOLOGY TRANSFERS

<u>No.</u>	<u>Status</u>	
MAT-16	A2U	The Concentration of Waste Heat Recovered from Stack Gas and/or Waste Waters
MAT-19	A4U	Power Factor Control System for AC Induction Motors
MAT-22	A3U	Improved Voice Communications in High Noise Level Environment
MAT-28	A3U	Testing Bearings While In Use
MAT-46	A3U	Tool Wear Sensing Using Vibration Analysis
MAT-54	A3U	Non Destructive Testing of Spot Welds
MAT-55	A3U	Non-Contracting 3-D Inspection Probe
MAT-59	A2U	High Quality Nickel Alloy Powder
MAT-71	A4C	Computer Aided Design of Sand Casting Molds
MAT-72	A3U	Nickel Based X-Ray Film Process
MAT-74	A3U	Controlling the Thickness of Conformal Coating for Printed Circuit Boards
MAT-82	A3U	Automatic Laser Inspection of Printed Circuit Boards
MAT-83	A2U	Adhesive Bonding of Aluminum
MAT-86	A4C	Adaptively Controlled Weld Skate
MAT-87	A3U	Low-Intensity Portable X-Ray Device
MAT-100	A5U	High Temperature Plastic
MAT-117	A3U	New Cutting Tool Material
MAT-118	A3U	Protective Coating for Die Casting Dies
MAT-131	A3U	Reliable, Economical, Fast Manipulator Arm
MAT-143	A3U	Single Fill Point Battery Reservoir

Table 5- 1

● MAT-100, High Temperature Plastic. A supplier of food processing equipment is using NASA developed (Tech Brief 71-10441) Polyimide plastic as a cover for trays and portions of trays. In the application of the new plastic it is being exposed to temperatures as high as 500⁰F. Preliminary test results show that the material works well and enables a 20% reduction of energy to heat the contents of the tray. Additional testing is underway but the source is optimistic that it will perform successfully. The MATeam is presently exploring additional applications of the plastic.

5.1 - Concentration of Waste Heat Recovered from Stack Gas and/or Waste Waters (MAT-16)

A large textile manufacturer wishes to recover the heat and latent heat from the moist flue gas effluent of textile drying ovens. This recovery can be made in several phases. First, the sensible heat from the flue gas can be transferred by a heat exchanger to heat the oven inlet air, which reduces the oven fuel consumption. Next the latent heat from the moisture in the flue gas can be recovered by condensing the flue gas. Third, the large volume of low temperature water could have the heat withdrawn and concentrated to form a small quantity of higher temperature fluid suitable for processing or heating. For this last process some form of heat pump would be required, possibly based on vapor absorption principles since the cost of mechanical compressors is high.

For the heat transfer function, heat pipe technology (as outlined in Tech Brief 71-10109) appears to be a possible solution. Isothermics, Inc. (New Jersey) was founded to exploit heat pipe technology under license from NASA. The company has equipment ranging from 100 CFM to 100,000 CFM at efficiencies varying between 20 and 80%. A heat design computer program enables a system to be designed to recover the moisture, heat and latent heat, from flue gases. Waste heat recovery using this technology is considered to have a high transfer potential.

No alternative to costly heat pump technology has been found yet.

Since up to 80% of recovery efficiency can be attained very considerable fuel savings accrue from heat pipe technology alone. The textile company representative was very interested in the information on heat pipe heat exchangers when informed in mid-January. Evaluation continues on their part in an effort to review the process equipment redesign implications.

5.2 Power Factor Control System for AC Induction Motors (MAT-19)

AC induction motors are one of the most commonly used in industry. In many applications they are relatively inefficient especially when operating at less than full load. The motor runs at essentially a constant speed which, within limits, is independent of load or applied voltage. Thus, in many instances, the power factor for the motor is higher than necessary.

Typically, a 115 volt motor would be designed to deliver its rated load plus a safety margin at an under voltage condition of 105 to 110 volts. In actual operation the motor seldom runs at full load and the line voltage is generally 120 to 125 volts. Hence the power factor is less than optimum and the copper loss within the motor is higher than optimum. The design of the motor is to be compatible with the constant voltage, constant frequency power distribution systems available.

What is needed is a relatively simple and inexpensive electronic circuit which would connect directly to the power lines of the motor, improve the power factor and significantly reduce the power dissipated in the motor at loads less than full load.

The solution to this problem was found in a NASA Tech Brief entitled, "Save Power in AC Induction Motors," by Mr. Frank J. Nola. The circuitry which was developed at Marshall Space Flight Center, is in essence an electronic control loop which varies the voltage applied to the induction motor.

The benefits of such a device would be energy savings, less heat generated by the motor and a better power factor which reduces power distribution costs.

Investigation into this high potential technology transfer has taken three major directions. First, Auburn University is currently doing theoretical analysis and testing of the device. Second, Marshall Space Flight Center has submitted an RTOP to NASA Headquarters for commercialization of the solution and a market study has been completed by IITRI. Finally, the MATeam is contacting key organizations in industry regarding commercialization.

5.3 Improved Voice Communication in High Noise Environment (MAT-22)

The ambient noise level is very high in some industries. Noise level reaches 105 dbA in textile mills and stamping plants and 120 dbA in casting cleanup shops. As a result verbal communication in such areas is very difficult. A representative of the textile industry requested that MATEam investigate the problem.

MATEam is in the process of making a second comprehensive computer literature search in the area of adoptive filtering techniques and poor signal to noise ratios. NASA technology such as MSC-12223-1 on "Audio Signal Processing Which Removes High Level Noise Burst" and 75A 34875* on, "A New VOX Technique for Reducing Noise in Voice Communication Systems" by P.E. Shock of Johnson Space Center are to be investigated for application to this problem. Briefly, narrow band limited spectra from the original voice signal are individually amplitude clipped and then recombined. If this technique does not suffice, then adaptive filtering techniques will have to be used such as one described in NASA-TM-X66080. The benefits of this technology will be that the staff will be able to communicate with one another in the noisy work areas which will improve their work efficiency.

The information has recently been forwarded to the problem/opportunity statement originator.

5.4 - Testing Bearings While in Use (MAT-28)

As a result of MATEam contacts with the engine and pump industries, there is interest in detecting incipient bearing failure before catastrophic damage can occur in very expensive machinery. Such machinery would be turbines of all types where bearing failure leads to immediate destruction of the whole turbine. Other machinery would be high speed machining centers where considerable damage could occur during the slow down period.

NASA has sponsored development of an Incipient Failure Detector described in NASA-MSC-16587. This detector has successfully checked motors, fans, and pumps for bearing integrity. This detector instrument performs vibration analysis on signals picked off accelerometer type sensors attached to the detector case. Since initial testing conditions are set into the detector, a wide range of conditions can be accommodated.

The benefits of such an instrument are that incipient failure can be detected and corrected before possibly catastrophic damage can occur. Such a bearing failure detector has high transfer potential to industry. A number of companies have been identified as being interested in the manufacture of these instruments and communication with them is in progress.

5.5 Tool Wear Sensing Using Vibration Analysis (MAT-46)

A large internal combustion engine manufacturer is interested in a detector that can sense metal cutting tool wear. The damage that results from tool failure in parts nearing the finished machine stage is costly and of great concern. The detector must be capable of monitoring wear on a continuous basis so that symptoms of tool failure may be identified prior to actual failure so replacements can be made.

The NASA sponsored Incipient Bearing Failure Detector uses vibration analysis methods in its detection scheme. This detector (reported in MSC-16587) can have initial parameters for the spectrum analysis inserted so that a wide variety of machining conditions can be monitored. The ability to detect a potential tool failure prior to its occurrence will have a major impact at reducing machining costs and losses incurred in the damage of parts that have neared final assembly or machining stages. The detection system has high application potential in the metal cutting industry.

The MATeam is in the process of contacting machine tool builders and cutting tool material manufacturers.

5.6 - Nondestructive Testing of Spot Welds (MAT-54)

Sheet metal fabricating industries have for several years voiced a distinct need for technology which will enable the nondestructive testing of spot welds.

The MATEam has identified, and is evaluating two ultrasonic inspection systems which have the potential to measure spot weld quality.

Among the most promising of these is a hand-held ultrasonic inspection device developed at Marshall Space Flight Center (NASA Tech Brief 66-10289). The system enables rapid scanning of spot welds for detection of a weld nugget. Its portability allows for the scanning of weldments in areas inaccessible to larger equipment.

Another nondestructive testing device currently being evaluated is a weld quality monitor (NASA Tech Book TND-5304) developed at Goddard Space Flight Center. This device was expressly designed to evaluate cross-wire resistance-welded joints used in electronic packaging.

Particular interest has been shown in these two testing devices by not only metal fabricating industries, but also key members of the non-destructive testing equipment industry. MATEam members are in contact with selected industry companies.

5.7 Non-Contacting 3-D Inspection Probe (MAT-55)

Current techniques for automatically inspecting 3-dimensional surfaces of complex parts rely on contacting probes. These probes must be frequently calibrated and are not suitable for inspection on non-rigid parts. Additionally, use of a contacting probe is time consuming and subject to damage if it collides with the part or fixturing.

Non-contacting inspection techniques exist for measuring 1- and 2-dimensional attributes of parts (e.g., size, location of features, and thickness). These are usually based on optical, electronic or magnetic sensors.

Although a non-contacting inspection technique would be of interest to many industries, our present target industry is shipbuilding. At present the shipyards use large wooden structures for alignment purposes. The structures are cumbersome to use and time consuming to fabricate. What is needed is a faster and more flexible method of controlling shipbuilding alignment operations.

A high potential transferable technology is the Optical Profilometer which was developed at Langley Research Center. The Optical Profilometer provides non-contact measurement of surface areas, absolute depth, and point-to-point distance using optical and electronic means. (NASA Ref.) The benefits of the solution will be a faster and more accurate system for shipbuilding construction operations.

The Optical Profilometer is currently being reviewed by a major shipbuilding manufacturer to determine how its capabilities can be applied to their alignment processes.

5.8 - Ultraclean, Ultrafine Rapidly Cooled Nickel Alloy Powder (MAT-59)

The aircraft turbine industry during the past ten years has been attempting to manufacture blades, discs, spacers and rotors from powdered alloys. The ability to obtain a high quality powder that after forging produces properties equivalent to wrought material has been a problem. Powders commercially available after being forged into parts produce microstructures containing high inclusion levels. The high inclusion levels promote low cycle fatigue failure when the parts are exposed to the rigorous high temperature and high stress environment.

NASA (Tech Briefs 66-10606, 69-10293, 70-10331, 70-10468, 72-10344) has produced a series of high quality nickel base alloy powders that have been produced using atomizing techniques and prealloyed powder. NASA test results have shown that the tensile strength properties of parts made from the powder are 1.5 to 2 times better than cast properties. In addition, the alloy has shown improved ductility at elevated temperature.

The major benefit in the availability of powdered parts is the cost saving obtained in the machining operation and the ability to produce a part with more closely controlled properties.

The problem originator and other key manufacturers in the aircraft turbine industry have demonstrated interest in the data and communications with them are underway.

5.9 - Improving Mold and Die Design Through Simulation of Casting Processes (MAT-71)

Casting processes (e.g., sand casting, permanent mold casting and die casting) are used to produce parts of complex shape in many metals and alloys. Cast metal parts are used in almost every product, from automobiles to household appliances. In 1971, the value of casting produced in the U.S. exceeded \$13 billion.

A major problem in the metal casting industry is product quality. Approximately 5 to 10 percent of the cost of all castings manufactured represent parts which are either scrapped at the foundry or rejected by the customer.

Much of the casting quality problem is attributable to the lack of readily available analytical techniques which can be used by foundry engineers to design casting systems. The design of the mold, gates and risers, and the selection of mold materials, the mold preheat temperatures, the temperature of the molten metal prior to pouring and rates at which the metal is injected into the mold all have a major impact on the quality of the casting produced. At best, techniques available to the foundry engineer make the design process and selection of casting parameters an art rather than a science. Additionally, because of cost and time constraints, the foundry engineer is not afforded the luxury of fine tuning his design and process parameters.

Computer aided design techniques which would enable the foundry engineer to design better casting systems at reduced costs and in shorter times are needed. An interactive computer system which would let the foundry engineer assess the impact of changes in casting system design would substantially improve product quality and reduce costs.

An interactive computer program can be used by foundry engineers to improve mold and die designs by simulating the solidification of metal which takes place during casting processes. NASA technology such as the "SINDA Systems Improved Numerical Differencing Analyzer", described in NASA Tech Brief B72-10736, and "Cosmic Program Abstract" MSC-13805, appear to be valuable bases for the technology required.

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MAT 71 (continued)

The technical feasibility of such a computer system has been demonstrated by Mr. William Erickson of Los Alamos Scientific Laboratory and it is anticipated that the Army sponsored project TARADCOM-(4785014) titled, "Improved Foundry Casting Processes Utilizing Computer Aided Fluid Flow and Thermal Analysis - CAM (Phase II)" will demonstrate further technical feasibility.

Major companies in the sand casting industry have been notified of the available technology and have responded with enthusiastic interest. Communications with selected industry representatives are in progress.

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5.10 Nickel Based X-Ray Film Process (MAT-72)

The inspection industry each year in the radiography of pressure vessels, large valves and castings use x-ray film containing costly silver emulsion that must be contained in light proof and radiation proof cassettes. The cost of the film is a major percentage of the price passed on to the industrial consumer.

The ability to reduce radiograph film costs is of interest to the industry.

NASA as described in Tech Brief B72-10456 has developed a new, less expensive nickel hypophosphite emulsion. The new emulsion is less sensitive to visible light. It has been determined that a new emulsion is (approximately 10^3) times less sensitive than required for industrial applications. Increased sensitivity (approx 10^5) is required for medical applications.

The benefits anticipated include reduced inspection and equipment costs. Improved radiograph quality is also envisioned.

The MATEam and The University of Wisconsin BATEam are presently contacting companies involved in the use and manufacture of film used in radiography.

5:11 - Controlling the Thickness of Conformal Coatings for Printed Circuit Boards (MAT-74)

One of the problems encountered during conformal coating of printed circuit boards is controlling the thickness of the coating during application. If the coating is too thin, sufficient environmental protection may not be achieved. Too thick of a coating on the other hand results in excessive production costs and may restrict cooling of the boards.

Current methods for controlling coating thickness depend on the type of coating used (dipping or vapor deposition). Dipped coatings are generally controlled by varying the viscosity of the coating and through the use of multiple coats. Vapor deposited coatings, such as parylene, are usually controlled by monitoring the deposition time. Parylene coatings can take several hours to achieve a thickness of 2 to 3 mils.

Other techniques for the control of thickness of conformal coatings are needed, particularly for the vapor deposition coatings.

The techniques should be low cost, provide an accuracy of less than 1 mil, be as free from human error as possible, and have an output which can be used for automatically controlling the process.

NASA, Lewis Research Center, has developed a technique for monitoring the thickness of parylene conformal coatings during deposition. The technique relies on the use of air-gap capacitors within the deposition chamber. The capacitance of these devices vary during the deposition process, and can be used in conjunction with an electronic circuit to automatically stop the process. The concept is simple, inexpensive and reliable. The benefits of this technology are reduced conformal coating cost, reduced scrap and rework costs and improved environmental performance.

Upon receipt of the technical brief, contacts will be made with potential users as well as potential equipment suppliers.

5.12 Automated Laser Inspection of Printed Circuit Boards (MAT-82)

During production at a large printed circuit board manufacturer, printed circuit boards are checked at several stages of manufacture in order that defects can be detected as early as possible so as to minimize corrections that must be made and to avoid discarding finished or near finished boards wherein errors are caught too late for easy, and thus inexpensive, correction. This, of course, requires considerable effort often involving both visual and electrical inspection. Presently most of this inspection is performed manually by a team of inspectors located at various points throughout the production line. Because of the time factor, such activity and expense, using the visual inspection team for high production rates of PC boards is unsatisfactory.

A company founded by ex-NASA employees has developed a laser scanning device based on experience with NASA laser holography and electronics in related projects (e.g., NASA-CR-123530). The NASA-based technology has resulted in inspection machines for detecting damaged holes, solder bridges, and miscripped components at each stage of manufacture.

The benefit foreseen in the laser inspection system is in the reduction of inspection costs with the in line adaptability of the system and elimination of the labor involved in the present inspection technique. Equally important is the inspection technique will be more reliable and do a better job than visual inspection.

Contacts have been made by the MATEam with a major supplier of electronic controllers serving the industrial market and the team is currently waiting for data on the system's performance requirements and configuration desired.

5.13 - Adhesive Bonding of Aluminum (MAT-83)

An aluminum boat manufacturer constructs boats from sheet aluminum riveted to prefabricated stringers and bulkheads. The manufacturer is experiencing difficulty in meeting OSHA noise standards of 90 dbA. He is interested in an adhesive bonding method for joining the boat shells to the bulkheads and stringers using methods similar to those of aerospace industry.

NASA has tested Hysol 934. They found that lap joints prepared with solvent cleaning and mild abrasion yielded joints of 95% of the strength of those etched with acid preparation. This is described in TK-X-71128. The benefits of this technology will be a quieter working environment.

The problem originator, the manufacturer of small sport fishing boats has been notified of the technology uncovered and has expressed interest in studying its applicability to his present fabrication practices.

Contact will be expanded to other sources in the boating industry to identify additional fabricators with similar problems.

5.14 - Adaptively Controlled Weld Skate (MAT-86)

The ability of a gas tungsten Arc GTA welding head to follow the irregular surface of a weld joint without a feeler probe and automatically adjust torch angle is a need of the welding industry. Welding equipment commercially available is not computerized and does not have the ability to automatically adjust torch angle. Further, a feeler probe is required to contact the joint surface to signal torch Y and Z position adjustment. Frequently the probes are damaged due to the heat of welding or give false direction as a result of rough contact surface.

NASA, in Technical Memorandum TMX-73328 developed a Computerized Adaptive Controls Weld Skate with Closed Circuit Television Weld Guidance. The system has the unique capability of tracking the weld joint in the transverse and longitudinal directions by computerized reflective light sensors. Torch angle is also adjusted to maintain a perpendicular relationship with the weld joint by a computerized system that initiates changes in torch angle by sensing increasing arc length.

The benefits anticipated in use of the system include reduced welding costs, reduced rework costs, and improved weld quality.

A major supplier of welding equipment has been located by the MATeam and has expressed interest in marketing the system after some additional development has been completed. The equipment manufacturer has forwarded a proposal to NASA for the additional development work and an R T O P is being prepared. The MATeam will continue to follow the program until successful implementation and assessment of results has been completed.

5.15 - Low-Intensity Portable X-Ray Device (MAT-87)

Fluoroscopic inspection devices are used to detect voids, porosity, inclusions and cracks in such items as castings, forgings, weldments and assemblies. Commercially available equipment is ordinarily large and bulky and requires that the work be taken to the test device.

A major drawback in the utilization of these devices is the need for a relatively high level source of x-rays. These x-ray sources are expensive and require the use of protective barriers. What is needed is a portable fluoroscopic inspection device which is sensitive to low level x-rays and can be taken to the work with relative ease.

NASA's Goddard Space Flight Center has developed a low-intensity portable x-ray device which addresses this problem. A patent is currently being filed on the device which is referred to as the Lixiscope.

Benefits anticipated in the availability of a portable device include reduced radiography costs, expanded non-destructive testing capability, good sensitivity at low energy x-ray levels, and will have wide application in the medical and dental field.

A market survey has been performed by IITRI under NASA Contract NASW02837 to identify the market potential of the device.

The MATEam will follow up on interested industrial sources identified as part of the market survey.

5.16 High Temperature Plastic (MAT-100)

A food processing equipment manufacturer is developing a new system for heating individual portions of food in institutions such as hospitals and prisons. The system utilizes induction coils which heat metal plates within the individual serving dishes, thereby warming the food. The serving dishes are ceramic and have metal bonded to the inside or outside, or totally embedded within the ceramic. In order to heat relatively large food items (e.g., steaks) it is necessary to have a cover on the serving dish which contains its own metal heating element. To prevent breakage and reduce weight, the covers should be plastic.

The temperature within the serving dish may reach as high as 500°F. The plastic cover itself may be exposed to higher temperatures than this because of the large heating element in the cover. This company has been unable to identify a commercially available plastic which can withstand the heat. The plastic covers should be capable of withstanding heats in excess of 600°F without outgassing. Such a plastic must be identified before the item can enter production.

NASA Lewis Research Center recommended Tech Brief 71-10441 on "Thermally Stable Polyimides from Solutions of Monomeric Reactants", Tech Brief 75-10137 on "Tailor Making High Performance Graphite Fiber Reinforced PMR Polyimides", and some suppliers of PMR polyimides they had tested. Lewis also recommended TMX 71894, "Second Generation PMR Polyimides".

The benefits of this technology will be 20% less energy required to process the food if cooked in the plastic lidded containers. Additionally in addition there will be less labor required to prepare the meals.

First and second generation resins were referred to the food processing equipment manufacturer who is in the process of testing them. Samples have been sent by the manufacturer to the National Sanitation Foundation to check their safety for food use. The preliminary findings are good. If the Foundations additional testing is satisfactory, they will use the suggested polyimide.

5.17 New Cutting Tool Material (MAT-117)

The metal removal industry is constantly searching for improved cutting tool materials. The application of new super alloys, alloys containing high hardness levels, and alloys containing hard coatings have created serious wear problems with cutting tools when machining has been required. In recent years the industry has had to rely on ceramic and cermet material cutting tools for difficult machining operations.

A cermet cutting tool material referred to as "Sialon" has been developed under NASA contract (patent No. 3,990,860). The material by JPL consists of 19% Si_3N_4 , 42% Al_2O_3 and 40% AlN and has been used effectively on Austenitic stainless steel and tungsten materials. It has performed better on these materials than some commercially available carbides.

The benefit to be gained in use of the material is principally lower machining costs as a result of less tool wear.

A major supplier of ceramic and cermet cutting tools contacted by the MATeam is presently performing machining tests using the Sialon cutting tool material.

5.18 Protective Coating For Die Casting Dies (MAT-118)

The die casting industry is concerned with the problem that molten aluminum alloys used in pressure die casting production are prone to "solder" or "weld" to the mold surfaces. When this occurs production is interrupted, die maintenance costs increase, casting surfaces are damaged and may be distorted or fractured during opening of the die halves or during ejection. What is needed is a coating or surface treatment that will prevent molten aluminum from attaching "welding" to the steel die components and facilitate release of the casting from the dies. Various commercial solutions have been tried but with limited success.

A promising solution is the Sputter Plating of a Solid Lubricant Tantalum Disizicide recommended by a coating specialist at Lewis Research Center. This technology was formerly tested by NASA as a protective coating under simulated reentry conditions and may have application.

Successful application of this solution would be of significant dollar cost benefit to the producers of aluminum die castings. There are an estimated 5,000 aluminum die casting machines in the United States. It has been conservatively estimated that the profit improvement that might from the elimination of the "soldering" problem could amount to over a dollar per machine hour. This adds up to over \$10,000,000 increased profit per year for the industry.

Presently the potential solution is being assessed by the user. Preparation of the testing set-up which will be used to evaluate its technical feasibility is in progress.

5.19 - Reliable, Economical, Fast Manipulator Arms (MAT-131)

The need for remote controlled robots and manipulator arms continues to grow with advancing technology in nuclear waste disposal, munitions deactivation and second generation mass production techniques. Industries involved in nuclear waste disposal, and munitions deactivation cannot risk exposure of personnel to the hazards of radiation exposure or explosives.

NASA has developed a manipulator arm described in MFS-22707 and patent 3,922,950 possessing small size, uniform motion control elements, and a counterbalanced power source. The design is simplified and the arm is of relatively low cost. The benefits of this technology are removal of humans from hazardous environments and mass production cost savings. Subsequent benefits include improved quality and elimination of the human error factor.

The MATeam is in the process of contacting manufacturers of remote controlled robots and industries in which they are widely used.

5.20 Single-Fill-Point Battery Reservoir (MAT-143)

The availability of a single-fill-point snap-on reservoir that can automatically restore the electrolyte solution in all cells of a storage battery is of interest to battery manufacturers. Existing storage batteries require that each cell be filled individually. This also necessitates individual maintenance and monitoring of these cells in certain cases, this is time consuming and not highly reliable. Although sealed automotive batteries have solved this problem, there are many storage battery applications which do not use sealed batteries.

Rockwell International, under contract to the Marshall Space Flight Center has developed a concept for a Snap-In Single-Fill-Point Battery reservoir as described in NASA Tech Brief MFS-16801.

The benefits to be obtained include low battery maintenance costs, its ease in adaptability to present battery design, and the ability to be visually monitored.

The MATEam has been in contact with battery manufacturers and a strong interest has been expressed by one company. The Tech Brief and other related technical data are or have been provided to the interested company.

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

a. The response of industry to participation in the program is far greater than anticipated. A valuable promotional technique in soliciting the response has been the use of press releases and announcements in selected trade journals.

b. The use of the problem/opportunity statement as a means to initially define and document a problem or opportunity is an effective, simplified method in which the screening and assessment system can function.

c. The technology transfer process appears to be an operational system that combines a critical assessment of the engineering and economic factors to be considered in the transfer of technology. The system provides a comprehensive analysis by engineering personnel with a wide range of industrial expertise that have the capability to identify transferable technology in situations that involve a problem and equally effective in the identification of NASA technology heretofore undetected that may adapt to areas of process improvement.

d. The screening of problem/opportunity statements is a slow process when considering the many assessment factors involved. The definition of the problem details, the search for relevant NASA technology that might solve the problem and assessment of the technical and economic factors are time consuming phases. It is estimated that the screening and assessment process for one statement takes eight weeks to perform.

Recommendations

a. It is suggested that timely press releases and published announcements continue in the trade journals. When a potential transfer has reached the level of Applications Engineering or Prototype Development an announcement or press release should be published in industry related trade journals.

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b. In promotion of the MATEam Program it is suggested that emphasis be placed in giving presentations before societies and associations representing a wide range of particular industries.

APPENDIX A

GUIDELINES FOR PREPARATION OF PROBLEM STATEMENTS

GUIDELINES FOR PREPARATION
OF

PROBLEM STATEMENTS

August, 1977

Manufacturing Applications Team
Engineering Research Division
IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616
(312/567-4609)

INTRODUCTION

The objective of the Manufacturing Applications Team (MATEam) is to successfully transfer aerospace technology to solve manufacturing problems in other industries. The MATEam begins with identification of problems and then seeks relevant technology which may provide solutions. Starting with the problems rather than available technology helps to insure that the MATEam's efforts are responsive to industry needs and that the amount of time spent in "finding problems for solutions" is minimized.

The MATEam identifies manufacturing problems by working with professional societies, industry associations, various government agencies and individual companies. Once identified, problems are documented in the form of problem statements, which are used by the MATEam throughout the technology transfer process.

This document has been prepared as a guide for individuals preparing problem statements for submission to the MATEam. It contains a description of how the problem statement is used by the team, the format employed and several examples.

FUNCTION OF THE PROBLEM STATEMENT

Problem statements play a key role in the MATEam's activities. They serve as a means of communicating information about the problem so that team members can:

- a. seek out potential solutions
- b. evaluate the likelihood of successfully solving a problem and implementing a solution and
- c. compare problems and concentrate on those which have the highest likelihood of solution and potential benefit.

In addition to its internal use, the MATEam circulates edited copies of the problem statements to technical personnel in the NASA field centers and laboratories. This helps insure that every effort is made to identify appropriate

technology if it exists. On occasion, this has resulted in innovative problem solutions based on the technical expertise of NASA personnel rather than on past NASA research and development. The problem statements are edited prior to circulation to NASA personnel to reserve the name of the problem originator and any information of a proprietary nature.

Copies of the problem statement are not circulated outside of NASA or the MATEam until a potential solution has been identified. If a potential solution has been identified, other organizations may be contacted to assess the magnitude of the problem and the suitability of the potential solution. Unedited problem statements are not circulated under any circumstances.

Problems which the MATEam will work on must meet three criteria:

1. The problem must be manufacturing related. This is very broad and could include materials, processes, inspection techniques, equipment, tooling, management techniques, energy conservation and product design as it relates to manufacturing.
2. The problem must apply to more than one company. The MATEam will focus on widespread problems and does not solve those problems which would benefit only one company. This would rule out the redesign of specific products or processes unless it involved an innovation which would be used by others. The MATEam will also not pursue problems for which there are acceptable commercially available solutions.
3. Solutions to problems must be based on NASA technology. Although NASA research and development has advanced the state-of-the-art in many areas, there will be many problems which cannot be solved using NASA technology. The problem originator is not expected to know in advance whether or not relevant NASA technology exists; this will be determined by the MATEam. If the MATEam identifies potential solutions involving technology from other sources, this information will be passed on to the problem originator.

As mentioned earlier, the problem statements are screened at several stages during the technology transfer process. The questions asked during the screening are:

1. Do satisfactory commercial solutions already exist for this problem?

2. What is the likelihood of identifying relevant NASA technology?
3. How widespread is the problem in industry?
4. What is the magnitude of the benefits to be gained by solving the problem?
5. Can the problem be solved technically?
6. Can a solution be implemented?

The answers to these questions are used to select those problems which the MATEam can most effectively solve. In those instances where a problem statement does not pass the screening process, the problem originator is notified and told the reason for the decision.

PROBLEM STATEMENT FORMAT

Problem statements are usually one to two pages in length and contain enough detailed information on which the MATEam can intelligently base a decision during their evaluation. Because of the large number of problem statements the MATEam reviews (several hundred per year), it is important that the problem statement be as concise and factual as possible. Additionally, because the problem statements will also be reviewed by NASA personnel who may not be familiar with manufacturing jargon, they should be written in layman's terms.

The problem statement format is shown in Figure 1. The problem statement should be typed doubled-spaced on plain bond paper. Additional information, such as reports and drawings, should be enclosed with the problem statement. Examples of completed problem statements are contained in Figures 2 and 3.

FIGURE 1. MATEam Problem Statement Format

TITLE:

ORIGINATOR: (Names of individual and company,
company address, and
individual's telephone number)

DATE:

WHAT'S NEEDED: (Brief one or two sentence description of solution
desired.)

BACKGROUND: (Description of product, current methods being used, and
why there is a problem. Also describe other approaches
which have been tried but have proven unsuccessful, and
why.)

SOLUTION CRITERIA: (Description of key factors, such as cost, performance,
material and production rates, which would determine
a successful solution.)

BENEFITS: (Description of what would be gained by solving the problem. This
could include such factors as cost savings, improved quality, im-
proved safety, etc. Also, the magnitude of the benefits for your
industry and other industries which may also use the solution
should be indicated, if possible.)

COMMENTS: (Optional, but may be used to describe NASA technology you are aware
of that may provide a solution or other approaches that should be
investigated. Any additional information concerning the problem or
solution which you feel is important should also be included in
this section.)

FIGURE 2. Example MATEam Problem Statement

TITLE: Submerged Arc Welding of Cast Steel Crankshafts

ORIGINATOR: Mr. Joe Doaks
Plant Manager
XYZ Company
10 West 35th Street
Chicago, Illinois 60616
(312/567-4609)

DATE: 8/1/77

WHAT'S NEEDED:

A method of controlling weld porosity when submerged arc welding cast steel.

BACKGROUND:

When rebuilding cast steel automotive crankshafts, under-sized bearing surfaces must be built up and then ground to the proper dimensions. This is currently being done using submerged arc welding. However, severe porosity has been encountered in the weld material. Forged steel crankshafts do not have this problem.

The cast steel crankshafts are cleaned in a caustic solution at 190^o-200^oF for 1-8 hours prior to welding. A variety of fluxes, welding wires, and torch angles has been tried without success. Undercutting of the bearing surfaces and pre-heating prior to welding also have not helped. Current procedures call for Page .035" 50P wire, Linde #58 flux, a 15 ^o torch angle from vertical, and welding 2 passes at 18-21 Volts and 150-180 Amps. Welding speed and wire feed are controlled automatically.

SOLUTION CRITERIA:

Solutions to this problem must be low cost. The cost to build up a single bearing surface should not exceed \$4.00 (does not include grinding down to size).

Additional criteria include:

- 1) Production rates in excess of 250 bearing surfaces per day.
- 2) A process which is either automatic or well defined so that unskilled labor can be used.
- 3) Hardness of the built-up material should be less than 35 R_C so that it can be easily ground to size.

BENEFITS:

Solutions to this problem would reduce rebuilding costs (approximately \$50 per crankshaft) by about 3% because of the current need to rework porous welds. Additionally, product quality would be improved and the cost of shipping defective units returned by customers would be eliminated. This is an industry-wide problem, and a solution would benefit many companies which weld cast steel.

COMMENTS:

None

1

FIGURE 3. Example MATEam Problem Statement

TITLE: Measuring Fabric Temperature in Ovens

ORIGINATOR: Mr. John Doe
Manufacturing Engineer
The Doe Fabric Company
10 West 35th Street
Chicago, Illinois 60616
(312/567-4609)

DATE: 8/1/77

WHAT'S NEEDED:

Instrumentation for measuring fabric temperature as it passes through drying ovens.

BACKGROUND:

In the textile industry, approximately 15 billion linear yards of fabric are processed annually through heating ovens (tenter frames) to remove residual water retained from previous processes, cure polymer finishes which are padded onto the fabric, and heat-set the fabric to controlled dimensions. In carrying out these processing steps, which are often done sequentially in the same oven, it is difficult to determine the temperature of the fabric.

Dwell times at predetermined temperatures are key factors in curing and heat setting fabrics. Fabric temperature remains below 100° until drying of water is complete, then increases to effect polymer finish curing and heat setting. Oven temperatures and fabric speed are controllable, but off-quality fabric results if either variable fails to create the required effect on fabric.

Current technology does not permit measurement of actual fabric temperature at selected points within the oven on a continuous basis. At present, the following deficiencies are noted in available temperature monitoring devices:

1. Optical devices are adversely affected by smoke from textile finishes and reflected energy from oven walls or apparatus inside the oven.

2. Optical units have to be located outside ovens or provided with special air or water cooling.
3. Contact type units create errors due to heat from friction.

SOLUTION CRITERIA:

Oven temperature is as high as 270°C, while fabric temperature varies from 30°C at entrance to oven up to 250°C at point of heat setting. Fabric linear speed through the oven varies from 40 yds/min. to 125 yds/min. depending upon fabric type and results required. The temperature sensing instrument should:

1. Have an accuracy of less than 1% error
2. Preferably not contact the fabric
3. Preferably not sense surface temperature, but rather average temperature
4. Withstand contaminated environment consisting of by-products from burning natural gas and smoke from fabric finish materials
5. Possess long-range reliability without continuous maintenance.

BENEFITS:

Monitoring and control of fabric temperatures will reduce off-quality fabric and increase throughput. Estimated annual value to the industry of a satisfactory solution is about \$25 million.

COMMENTS:

None

APPENDIX B
INITIAL SCREENING FORM

1st Screening of MATEam Problem/Opportunity Statements

Problem No. _____ Title _____ Date _____

Criteria

1. How large is the problem?

☐ Problem is unique to one company or product.

☐ Problem is unique to one industry.

☐ Problem may be found in many industries.

Comments: (e.g., who contacted, industries affected, etc.)

2. Do acceptable commercial solutions exist for the problem:

☐ Acceptable commercial solutions exist and are readily available.

☐ Proprietary solutions exist.

☐ Commercial solutions are not available.

Comments: (e.g., brief description of commercial solution)

3. What is the magnitude of potential benefits if this problem is solved:

☐ Small economic benefit (< \$50,000)

☐ Medium economic benefit (\$50,000 - \$250,000)

☐ Large economic benefit (> \$250,000)

☐ Significant intangible benefits (e.g., improved safety, better international competitive position, etc.)

Comments: _____

4. What degree of public visibility is associated with this problem:

☐ Low public visibility.

☐ High public visibility.

Comments: _____

5. How likely is it that NASA technology exists to help solve this problem:

☐ Not likely.

☐ Likely

☐ Almost certain.

Comments: (e.g., Field Centers, NASA personnel, report, tech briefs and areas of NASA technology that may apply).

6. Can this problem be solved technically?

☐ Yes.

☐ Possibly.

☐ No.

Comments: (e.g., current development work in this area.)

7. If a technical solution is achieved, can it be implemented?

- ☐ Implementation would be straightforward and could take place almost immediately.
- ☐ Implementation would require applications engineering and could take several years to achieve.
- ☐ Implementation would be difficult, if not impossible to achieve.

Comments: _____

XX

Based on this assessment, do you recommend:

- ☐ Problem be pursued further by the MATeam
- ☐ Problem be inactivated (Code I 1 ____)

Comments: _____

APPENDIX C

PRESS RELEASE



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E. P. Fahy
Special Events
Ext. 4026

April 21, 1977

FOR IMMEDIATE RELEASE

NASA ESTABLISHES MANUFACTURING APPLICATIONS TEAM

CHICAGO -- NASA's Marshall Space Flight Center, Huntsville, Alabama, has awarded a one-year contract to the IIT Research Institute (IITRI), Chicago, to establish a manufacturing applications team as part of the agency's Technology Utilization Program.

Under the terms of the contract, IIT Research Institute will form a Manufacturing Applications Team (MATeam) composed of technical experts who will work with professional societies, industry associations, various government agencies and individual companies to define significant and widespread manufacturing problems and identify the appropriate space technology for potential solutions. In addition to identifying appropriate technologies, the team, in cooperation with NASA and industrial organizations will attempt to demonstrate solutions by conducting applications engineering work and developing prototypes when appropriate.

During the first year of the program, the team will concentrate its efforts on working with manufacturing industries in such areas as machine tools, heavy equipment, electronics assembly and light fabrication and assembly. If the concept is successful the contract will be extended and the team will expand its scope of operation to include other industries.

(more)

ADD ONE - NASA ESTABLISHES MANUFACTURING APPLICATIONS TEAM

The MATEam is being funded as part of NASA's Technology Utilization Program which is aimed at increasing the nations's return on investment in aerospace research by assuring that the benefits of this technology are made available to all sectors of the economy. The NASA Technology Utilization Office already operates applications teams in the medical, transportation, environment and local and state government areas.

Organizations are encouraged to participate in this program and if interested should contact the MATEam Director, Mr. John D. Meyer, IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616, telephone 312/567-4609.

APPENDIX D

MATEAM PROBLEM STATEMENTS AND STATUS

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<u>MAT #</u>	<u>TITLE</u>	<u>STATUS</u>	<u>COMMENTS</u>
1	High Friction Gasket Material	I2B	Unable to identify NASA technology
2	Measurement of Shrinkage in Textiles	I1D	Inactive - Low potential benefits
3	Humidity Measurement in Air in Textile Ovens	I2B	Unable to identify NASA technology
4	Automatic Equipment for Producing Film Belts	I3F	Likelihood of implementation is low
5	Chemical Etching of Aluminum	I2B	Unable to identify NASA technology
6	Measuring Fabric Temperature in Ovens	I2B	Unable to identify NASA technology
7	Submerged ARC Welding of Bearing Surfaces on Cast Steel Crankshafts	I2B	Unable to identify NASA technology
8	Natural Gas Filters for Kitchen Ranges	A2U	Information gathering phase. Literature survey obtained
9	Surface Finish for Appliances	A2U	In contact with Johnson Space Center
10	Conformal Coating of Printed Circuit Boards	A2U	Gathering all relevant NASA technology
11	Techniques for Measuring Vibration in High Speed Shafts	I1A	Commercial solution available
12	Fabrication of Tubular Stamped Parts	I1C	Problem is unique to company
13	Forming of Titanium Foils	A2U	Information gathering phase
14	Improved Methods for Cleaning and Plating of Cast Iron Cylinder Liners	A2U	Checking all possible sources
15	Controlled Deposition of Fine-Grain Powder onto Fabrics	A2U	Checking all possible sources
16*	Concentration of Waste Heat Recovered from Stack Gas	A2U	NASA technology referred to client
17	Flame-Retardant Treatment for Cotton and Polyester Fabrics	A2U	Johnson technical monitor already doing research in related areas
18	Sculpturing of Glass Using Numerical Control	I2B	Unable to identify NASA technology
19*	Power Factor Control System for AC Induction Motors	A4C	Implementation strategy being developed

* Potential technology transfer

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20	Evaluation and Control of Stresses, in Super-Alloys, Resulting from Metal Working Processes	I2D	Inactivated, potential benefits are low
21	Permanent Treatments to Modify Surface Friction of Fibers	I2B	Unable to identify NASA technology
22*	Improved Voice Communications in High Noise Level Environment	A3U	Gathering information
23	Durable Anti-Reflective Treatment for Fabric Surfaces	I2B	Unable to identify NASA technology
24	Recovery of Sand from Shell Molding Process	I2B	Inactivated, no relevant NASA technology
25	High Temperature Binder for Sand Molds	A2U	Gathering data
26	Bonding of Brass to Aluminum	I2A	NASA suggested commercial processes
27	Automated Techniques for Assembling Clock Faces	I1C	Too specialized
28*	Testing Bearings While in Use	A3U	Gathering information
29	Improved Switches for Portable Electric Tools	A1U	Gathering data
30	Predicting Model for Relating Super-Alloy Microstructure/Properties to Machinability of Isotatically Forged Powder Metallurgy Components	I2B	No relevant NASA technology
31	Evaluation of the Machinability of Scales Resulting from Metalworking Processes	A2U	Information gathering phase Literature survey obtained
32	Metallurgical Variables Affecting the Machinability of Sintered Steel	A2U	Information gathering phase Literature survey obtained
33	Relating Variabilities in Work and Tool Materials to Machining Productivity	A2U	Information gathering phase Literature survey obtained
34	The Role of Inclusions in the Machinability of Commercial Alloys	A2U	Information gathering phase Literature survey obtained
35	Economic Evaluation of Isothermal Forging of Transage Alloys	A2U	Information gathering phase Literature survey obtained
36	Powder Metallurgy Engine Bearings	A2U	Checking NASA sources; Originator to be contacted for more information
37	Automatic Feed System for Hand-Held Bland Rivet Gun	I2B	No NASA technology available

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38	Inertia Welding	I2A	Inactivated, commercial solutions exist
39	Automated Installation of Both Solid and Blind Rivets, Including Automatic Positioning and Cycle Controls	I2A	Commercial solution available
40	Assembly of Mechanical Devices and Electronic Circuits with Robotics	I2G	Insufficient data
41	Combined Automatic Riveting and Rivet Shaving	I2B	No available NASA technology
42	Optimization and Control of Composite Fabrication Processes	A2U	Currently checking NASA sources
43	Adaptability of Frequency Analysis Techniques to the Optimization of Machine Tool Spindle Power	A2U	Gathering NASA information
44	Fabricated Forging Equivalents	I2B	No relevant NASA technology
45	Direct Linear Control of Machine Tool Slides	A2U	Evaluating NASA solution
46*	Tool Wear Sensing Using Vibration Analysis	A3U	Gathering information
47	Improved Inspection Accuracy of Machined Components	I2G	Originator not specific enough
48	Protection of NC Equipment Against Power Surges	I1A	Commercial solution available
49	Handbook for Analysis Techniques for Capital Equipment Justification	I2A	Commercial solution available
50	FORTTRAN Translator	I1A	Commercial solution exists
51	Materials Handling of Large Parts in Machining	A2U	Currently checking NASA sources
52	Location of Material in Job Shop	A2U	Gathering information
53	Limited Life Item Management Handbook	A2U	Considering NASA in area for possible publication
54*	Nondestructive Techniques for Spot Weld Testing	A3U	Marshall Space Center contacted about work in area
55*	Non-Contacting 3-D Inspection Probe	A3U	Solution assessment under way, very promising
56	In-Process Inspection and True Position Control of NC Profile Milling Machines	I2G	Insufficient Data

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57	Ultra High Speed Spindle N/C Multiple Axis Machining Center	A2U	Currently corresponding with interested parties, a very desirable transfer
58	Pulsed Laser Machining	A2U	Lewis Research Center is likely source of solution, promising
59 [*]	Ultraclean, Ultrafine, Rapidly Cooled Nickel Alloy Powder	A2U	Checking NASA sources; originator needs to supply more input
60	Nontraditional Machining Guide Books	I1A	Inactivated, commercial solutions exist
61	Reduction of Machining Costs by Valve Engineering Approach	I1A	Commercially available solutions
62	Application of CAM to Organization, Layout, and Sequence of Operations for Machine Tools and Auxiliary Equipment	A2U	Second literature search in progress
63	Integration of Engineering and Manufacturing CAD/CAM Systems	A2U	Second literature search in progress
64	Alternate Materials/Production Process for Fabrication of Microwave Components	I2B	No available NASA technology
65	Diagnostic Testing of N/C Controllers	I2E	Unable to identify acceptable technical solution
66	Air Conditioning for N/C Control Units	I1A	Commercial solution available
67	Material Handling of Precision Components	I1D	Low potential
68	Precision Grinding Techniques	A2U	Checking NASA sources
69	Precision Surface Finish Inspection Techniques	A2U	Checking NASA sources
70	Cleaning of Lapped Parts	I2B	Unable to locate NASA technology
71 [*]	Computer Aided Design of Die Casting Dies	A4C	Army to fund project
72	Nickel Based X-Ray Film Process	A3U	Contacts with industry in process
73	Friction Reduction Between Contacting Surfaces	A2U	Will send possible NASA solution to user
74 [*]	Controlling the Thickness of Conformal Coatings for Printed Circuit Boards	A3U	Solution being assessed

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75	Controlling Noise of Sliding or Rolling Equipment ;	A2U	Seeking NASA technology
76	Improved Method of Cutting Gear Teeth with Emphasis on Lasers	A2U	Connected with MAT-58
77	Computer Aided Production Process Planning	A2U	Searching for NASA technology
78	Electro-Mechanical Straightening/Alignment Techniques for Damaged Automobile Frames	A2U	NASA technology possibly identified; originator has offered manpower for development of solution
79	Removal and Replacement of Conformal Coatings	A2U	Gathering information
80	Improved Flux for Stud Welding of Aluminum	I3D	Potential benefit low
81	Fabrication of Bi-Metallic Cells	I2A	Commercial solution available
82*	Automatic Laser Inspection of Printed Circuit Boards	A3U	Solution assessment underway
83*	Adhesive Bonding of Aluminum	A2U	Presently compiling information regarding all aspects of NASA work in area
84	Tungsten Inert Gas Welding of Unalloyed Titanium	A2U	Compilation of NASA technology to begin shortly
85	Automatic Assembly and Testing of Electronics	A2U	Gathering information
86*	Adaptively Controlled Weld Skate	A4U	Further development planned with industrial source
87*	Low-Intensity Portable X-Ray Device	A3U	Industrial sources being contacted
88	Recovery and Regeneration of Solvents by Automatic Control	A1U	Problem definition
89	On-Line Analysis of TNT and Intermediate Products	A1U	Problem definition
90	Biological Warning System	I2B	Unable to identify NASA technology
91	Early Warning System to Predict Mechanical Failures	A2U	Gathering information
92	Nondestructive Testing of Cast Explosives	A2U	Checking NASA sources

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93	Detection of Surface Flaws Using Laser Holography	A2U	Checking NASA sources
94	Nondestructive Hardness Testing Using X-Ray Diffraction Techniques	A2U	Checking NASA sources
95	Polymer Finishes for Magnesium Alloy Parts	I1C	Problem seems too unique
96	Thermographic Inspection of Optical Bonds	A2U	Gathering information
97	RF Curing of Adhesive Bonded Components	I2B	Unable to identify relevant NASA technology
98	Electromagnetic Forming of Weapon Components	A2U	Information gathering under way; literature survey obtained
99	Bonding of Metal to Ceramic	I3F	NASA techniques found to be unsatisfactory
100 [*]	High Temperature Plastic	A5U	Applications engineering underway by user
101	Co-Deposition of Solid Lubricants During Anodizing	A2U	Promising, probable source for solution is Lewis Research Center
102	Preventing Hydrogen Embrittlement	A1C	Statement preparation complete
103	Co-Deposition of Solid Lubricants During Plating	A2U	Promising, probable source of solution is Lewis Research Center
104	Plasma Arc Assisted Machining	A2U	Promising, probable source of solution is Lewis Research Center
105	In Process Technique for Balancing Drive Shafts	A2U	Currently reviewing literature search
106	Inspection of Lamination in Thin Sheet Steel	A2U	Checking NASA sources
107	Stable Thin Film Resistors	I2E	NASA techniques found, so far proved inadequate
108	Reduction of Noise Levels from Portable Handgrinding Operations	A2U	No NASA techniques found yet
109	Balancing Drive Shafts Economic Method of Selecting Bearings to Ensure Perfect Fit	A2U	Currently seeking a solution, not promising

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110	Laser Curing of Resins	A2U	Checking NASA sources; requested more specific information from originator
111	Optical Inspection of Clutch Plates	A2U	Currently seeking a solution, not promising
112	Laser Inspection of Bond Quality of Phenolic Resins	A2U	Checking all NASA sources, need more input from originator
113	Using Lasers to Measure Cure State of Phenolic Resins	A2U	Checking all NASA sources, need further information from originator
114	Use of Cast Iron Components in Oil and Gas Transmission	I1B	No NASA technology available
115	Contingency Planning for Hazardous Environments	A2U	Possible publication
116	Automatic Guidance of Farm Tractors	A2U	NASA techniques found, so far are inadequate
117	New Cutting Tool Material	A3U	Evaluation tests in progress
118*	Protective Coatings for Die Casting Dies	A3U	Very promising, solution testing under way
119	Submersed Injection System for Aluminum High Pressure Die Casting	A2U	Currently seeking a solution, promising
120	Programmable Fixturing Devices	A2U	Gathering information
121	Geometric Modeling of Parts	A2U	Gathering information
122	Alternative to Stainless Steel for Use as Food Contact Surfaces	A2U	Information gathering under way, literature search requested
123	Alternatives to Carbon Bearing Rubber as Used in Food Contact Surfaces	A2U	Information gathering under way, literature search requested
124	Alternative Refrigerant to Fluorocarbon	A2U	Checking NASA sources
125	Biodegradable Food Packaging	I1G	Inactivated, insufficient information
126	Cleanliness Testing of Product Contacting Surfaces	A2U	Information gathering under way
127	Synthetic Sweeteners	I1G	Inactivated, insufficient information
128	Substitute for Sugar	I1G	Inactivated, insufficient information

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129	Synthesis of Food from Atmospheric Elements	IIG	Inactivated, insufficient information
130	Programmable Parts Handling Equipment	A2U	Information gathering phase
131	Reliable, Economical, Fast Manipulator Arms	A3U	Solution Assessment under way
132	Improved Welding Procedures for Aluminum Alloys	A2U	Checking NASA sources
133	Technique for Determining Strip Width for Forming Welded Steel Tubing	A1U	Problem Definition
134	Design of One Piece Nut Rings	IIC	Problem is unique to company
135	Improved Press Fitting Methods	AIC	Problem definition complete
136	Tantalum Capacitor Positive Lead Attachment	A2U	Information gathering phase
137	Tantalum Capacitor Negative Lead Attachment	A2U	Information gathering phase
138	Small Permanent Magnets to Attach Mailbox Signals to Mail Boxes	IIC	Inactivated, insufficient information
139	Photographic Image Intensification	I3E	Unable to identify relevant NASA technology
140	Manipulator Arm Bin Picking	I1A	Inactivated, commercial solutions exist
141	Improved Arc Shield Machining	A2U	Information gathering phase
142	The Recycling of Water Used in Paint Pretreatment System	A1U	Statement being prepared
143	Single Fill Point Battery Reservoir	A3U	Contacting potential manufacturer
144	Low Friction Surfaces for Machine Slideway System	A1U	Statement being prepared
145	Shock Absorbing Hydraulic Fluid	A1U	Statement being prepared
146	Chrome Plating Long Shafts	A1U	Statement being prepared
147	Bearings for High Speed Machine Spindle Heads	A1U	Statement being prepared
148	Composite Materials for Machine Bases and Structures	A2U	Information gathering stage
149	Hot Machining	A1U	Statement being prepared
150	Measuring the Case Hardened Depth Using N.D.T.	A1U	Statement being prepared